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ELEMENTAL ABUNDANCES VS. KINEMATICS IN THE MILKY WAY'S DISK

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Abstract. We present the results of our investigation of three samples kinematically representative of the thin and thick disks and the Hercules stream using the catalogue of Soubiran & Girard (2005). We have observed abundance trends and age distribution of each component. Our results show that the two disks are chemically well separated, they overlap greatly in metallicity and both show parallel decreasing trends of alpha elements with increasing metallicity, in the interval -0.80 < [Fe/H] < -0.30. The thick disk is clearly older than the thin disk with a tentative evidence of an AMR over 2-3 Gyr and a hiatus in star formation before the formation of the thin disk. In order to improve the statistics on the disk's abundance trends, we have developed an automatic code, TGMETα, to determine (Teff, logg, [Fe/H], [α/Fe]) for thousands of stellar spectra available in spectroscopic archives. We have assessed the performances of the algorithm for 350 spectra of stars bieng part of the abundance catalogue.

1 Abundances

We have compiled a large catalogue of stars from several studies from the literature presenting determinations of O, Na, Mg, Al, Si, Ca, Ti, Fe, Ni abundances (Soubiran & Girard 2005). Because authors of the different studies do not use the same scales and methods in their spectral analyses, systematics between their results have been investigated (for more details on the construction of the catalogue see Soubiran & Girard 2005). The final catalogue of abundances includes 743 stars.

In order to study kinematical groups of the Milky Way's disk we need velocities and orbits of stars from the abundance catalogue. We first cross-correlated the catalogue with Hipparcos (ESA 1997), selecting stars with π >10 mas and $\frac{\sigma_\pi}{\pi}$ <0.10. Then we have searched for radial velocities in several sources. Distances, proper motions and radial velocities have been combined to compute the 3 components (U, V, W) of the spatial velocities with respect to the Sun and the orbital parameters for 639 stars. In addition the derivation of ages was kindly done by Frédéric Pont making use of the Bayesian method of Pont & Eyer (2004). Good estimations of ages were obtained for 322 stars from the abundance catalogue.

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2 Kinematical classification

In order to investigate the abundance trends in the thin and the thick disks separately, we have classified the stars into the 2 populations, using kinematical information. A third component, the Hercules stream recently revisited by Famaey et al. (2004) has kinematical parameters intermediate between the thin disk and the thick disk. Its stars could have polluted previous samples of thick disk stars selected on kinematical criteria and thus must be taken into account. According to the known velocity ellipsoid of these 3 populations, we assign a membership probability to each star and select respectively 428, 84 and 44 stars having a high probability to belong to the thin disk, the thick disk and the Hercules stream respectively. The (U, V) plane of the whole sample is shown in the Fig. 8 in Soubiran & Girard (2005).

3 Abundance trends and ages: results and discussion

The abundance trends for each kinematical group are shown in Fig. 1. In addition we have represented the distribution of ages vs. [Fe/H] for stars having well-defined ages for the thin disk, the thick disk and the Hercules stream (see Fig. 12 in Soubiran & Girard 2005).
Our results confirm previous well established findings:

- The thin disk and the thick disk overlap in metallicity and exhibit parallel slopes of [α/Fe] vs [Fe/H] in the range -0.80 < [Fe/H] < -0.30, the thick disk being enhanced.
- The thick disk is older than the thick disk.

We bring new constraints on more controversial issues:

- The thin disk extends down to [Fe/H]=-0.80 and exhibits low dispersions in its abundance trends.
- The thick disk also shows smooth abundance trends with low dispersions. The change of slope which reflects the contribution of the different supernovae to the ISM enrichment is visible in [Si/Fe] vs [Fe/H] and [Ca/Fe] vs [Fe/H] at [Fe/H] $\simeq$ -0.70, less clearly in [Mg/Fe] vs [Fe/H].
- Al behaves as an α element.
- [O/Fe] decreases in the whole metallicity range with a change of slope at [Fe/H] = -0.50 for the 3 populations.
- An AMR is visible in the thin disk, the most metal-poor stars having 6.2 Gyr on average, those with solar metallicity 3.9 Gyr.
- Ages in the thick disk range from 7 to 13 Gyr with an average of 9.6 $\pm$ 0.3 Gyr. There is a tentative evidence of an AMR extending over 2-3 Gyr.

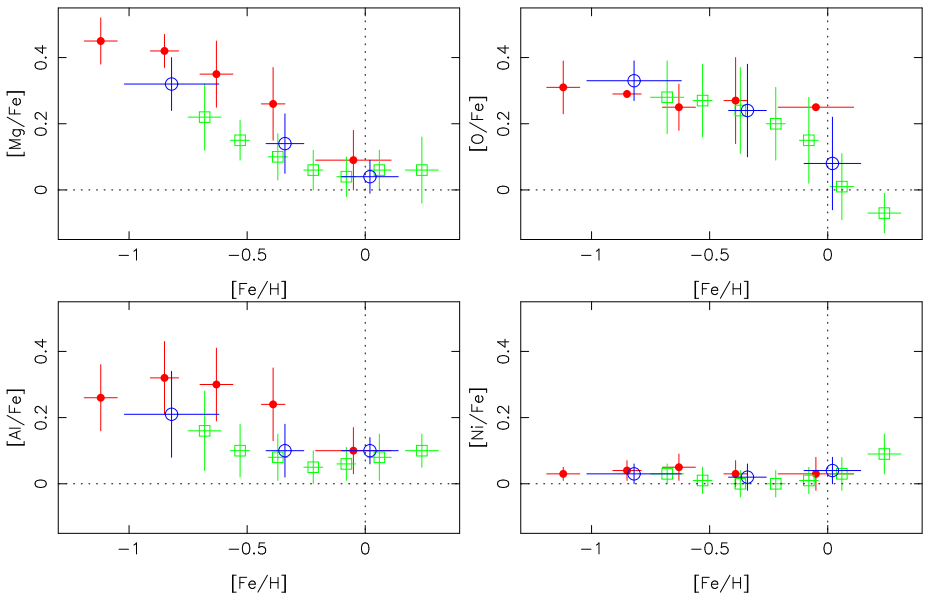

Fig. 1. Averaged [X/Fe] vs [Fe/H] per bin of metallicity in the thin disk (green squares) in the thick disk (red filled circles) and in the Hercules stream (blue open circles). Errors bars correspond to the standard deviations around the mean value in each bin. Note that Si, Ca, Ti and Na elements are not represented here but can be found in Soubiran & Girard (2005).

- The most metal rich stars assigned to the thin disk do not follow its global trends. They are significantly enhanced in all elements (particularly in Na and Ni) except in O which is clearly depleted. They have also a larger dispersion in age. Half of these stars are probable members of the Hyades-Pleiades supercluster, two others are surprisingly old.

4 Perspectives

The investigation of abundances trends in the disk is currently limited by the low number of stars having known abundances, all being in the close solar neibourhood. In order to improve the statistics and reach larger distances, automatic methods of spectral analysis have to be developed. This is especially crucial in the perspective of GAIA which will produce millions of stellar spectra with substancial information on elemental abundances. We have developped a code, TGMETα, to determine automatically (Teff, logg, [Fe/H] and [α/Fe]) on a criterion of minimum distance with respect to the grid of synthetic spectra of Barbuy et al. (2003). We have assessed the performances of this algorithm on high resolution spectra of 350 stars being part of the abundance catalogue. We compare in Fig. 2 the [α/Fe] ratio

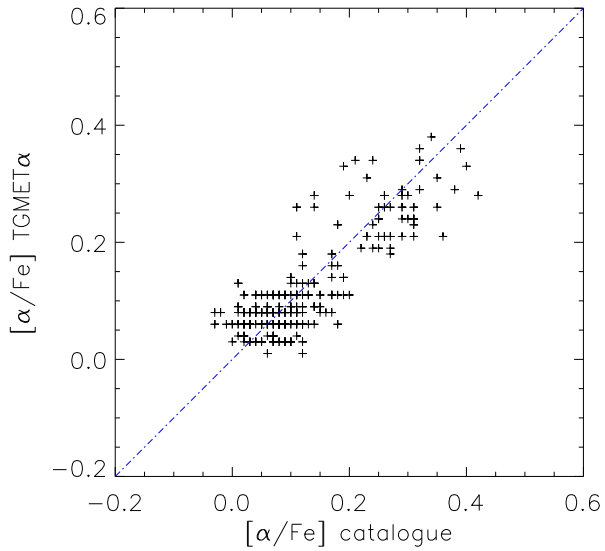

Fig. 2. The [α/Fe] ratio from TGMETα vs. the same ratio from the reference catalogue of abundances.

obtained with TGMETα to those from the catalogue, considered as reference values. The low dispersion, 0.05 dex, and the lack of systematic difference ensure that indeed reliable abundance ratios can be obtained automatically, at least at high resolution. Future investigation will concern low S/N or low resolution spectra and other grids of synthetic spectra.

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